

WHAT IS CLAIMED IS:

1 1. A catheter for removing material from a body lumen, said catheter
2 comprising:
3 a catheter body having a proximal end and a distal end;
4 a material capture device arranged on said catheter body to engage said
5 material; and
6 a cutting element mounted near the distal end of the catheter body to move
7 between a first position and a second position to cut said material while said material is
8 engaged by said material capture device, wherein motion of the cutting element urges the
9 material capture device to draw cut material into the catheter body.

1 2. A catheter as in claim 1 wherein said catheter body comprises a
2 proximal, flexible portion and a distal, rigid portion containing said cutting element.

1 3. A catheter as in claim 2 wherein said catheter body comprises a
2 inner cutter mounted coaxially within said distal, rigid portion, said material capture
3 device mounted on said inner cutter.

1 4. A catheter as in claim 2 wherein said catheter body comprises an
2 atraumatic distal tip mounted on said distal, rigid portion.

1 5. A catheter as in claim 1 wherein:
2 said material capture device is arranged on said catheter body to advance
3 along a path outwardly from the catheter body into said material and then inwardly
4 towards the catheter body to tension said material; and
5 said cutting element on said catheter body moving between said first
6 position and said second position to cut said material while in tension.

1 6. A catheter as in claim 5 wherein said path comprises a radially
2 curved path extending in an outward direction away from the catheter body towards said
3 material to be cut off.

1 7. A catheter as in claim 6 wherein said material capture device
2 moving along said path does not exceed the outer diameter of the catheter body.

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1 8. A catheter as in claim 5 wherein said material capture device
2 travels in a slot on the catheter body to advance along said path.

1 9. A catheter as in claim 5 wherein said material capture device
2 travels in a groove on the catheter body to advance along said path.

1 10. A catheter as in claim 5 wherein said material capture device
2 comprises a bias element to urge said material capture device along said path.

1 11. A catheter as in claim 5 wherein said material capture device is
2 configured to rotate about a pivot pin to deploy said material capture device along said
3 path.

1 12. A catheter as in claim 1 wherein said material capture device
2 comprises:
3 a penetrating member pivotably mounted about a pin on said cutting blade,
4 said penetrating member movable between a first, tissue-engaging position and a second
5 tissue-retracting position; and
6 a cam surface disposed on said catheter body to contact and rotate said
7 penetrating member about said pivot point when said cutting blade is advanced over the
8 cam surface.

1 13. A catheter as in claim 12 wherein said cam surface is configured to
2 slidably contact a lower surface on said penetrating member to guide said penetrating
3 member over an accurate path as the cutting blade is advanced.

1 14. A catheter as in claim 13 wherein said cam surface includes a
2 groove for mating with said penetrating member.

1 15. A catheter as in claim 13 wherein said cam surface includes a first
2 groove having a funneled opening and a second groove having a second funneled
3 opening.

1 16. A catheter as in claim 13 wherein said penetrating member
2 comprises a recess on said lower surface to facilitate positioning of said member over said
3 cam surface.

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1 17. A catheter as in claim 1 wherein said material capture device
2 comprises:
3 a penetrating member rotatably mounted on said cutting element; and
4 an abutment disposed on said catheter body to engage one end of the
5 penetrable member and cause rotation of the penetrating member from a first, open
6 position to a second, closed position.

1 18. A catheter as in claim 17 further comprising a tether coupled to
2 said penetrating member to control positioning of the penetrating member.

1 19. A catheter as in claim 1 wherein said material capture device
2 comprises a penetrating member rotatably mounted on said catheter body and fixedly
3 secured relative to said slidable cutting element;
4 a pushing element mounted on said cutting element to engage said
5 penetrating member to move said member between a first position to a second tissue-
6 engaging position.

1 20. A catheter as in claim 1 wherein said material capture device is
2 configured to be deployed from an aperture in the side wall of the catheter body.

1 21. A catheter as in claim 20 wherein said cutting element includes an
2 material imaging device mounted to be in an imaging position when said aperture is
3 closed by said cutting element.

1 22. A catheter as in claim 1 wherein said cutting element includes a
2 first cutting blade having at least one penetrating point.

1 23. A catheter as in claim 1 wherein said cutting element has a first
2 cutting blade opposed to a second cutting blade for removing said material.

1 24. A catheter as in claim 1 wherein said cutting element comprises a
2 tubular inner cutter slidably mounted within an outer cutter of the catheter body, said
3 inner cutter coupled to a drive wire actuated by a user.

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1 25. A catheter as in claim 1 wherein said material capture device
2 extends an extension distance outward from the catheter body to engage material, said
3 extension distance equal to the diameter of the catheter body.

1 26. A catheter as in claim 1 wherein said material capture device
2 includes a barbed distal tip to retain material on the capture device.

1 27. A catheter as in claim 1 wherein said cutting element further
2 comprises a material imaging device.

1 28. A catheter as in claim 27 wherein said material imaging device
2 comprises an ultrasound transducer array.

1 29. A catheter as in claim 1 wherein said material capture device
2 comprises means for penetrating said material.

1 30. A catheter as in claim 29 wherein said means for penetrating
2 material comprises a curved needle biased outwardly from the catheter body.

1 31. A catheter as in claim 29 wherein said means for penetrating
2 material comprises a penetrating member rotatably mounted about a pivot pin on said
3 cutting element.

1 32. A catheter as in claim 29 wherein said means for penetrating
2 material is configured to engage a raised portion on said catheter body to move said
3 means to engage material and then retract material into the catheter body.

1 33. A catheter as in claim 32 wherein said raised portion comprises a
2 cam surface having a plurality of tracks, wherein each track has a funneled entrance to
3 guide said penetrating member therein.

1 34. A catheter for removing material from the wall of a body lumen,
2 said catheter comprising:
3 a catheter body having a proximal end and a distal end;
4 a side aperture on the catheter body;
5 a cutting blade adapted to advance past the aperture to sever material
6 which intrudes through the aperture; and

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7 a penetration member mounted to extend through the aperture to penetrate
8 material in advance of the cutting blade and to draw material into the catheter body as the
9 cutting blade is advanced past the aperture.

1 35. A catheter as in claim 34 further comprising a cam surface
2 mounted on said catheter body, said cam surface having a surface configured to guide
3 said penetration member into said material when said blade is advanced.

1 36. A catheter for removing material from a body lumen, said catheter
2 comprising:
3 a catheter body having a proximal end and a distal end;
4 a material capture device arranged on said catheter body to advance along
5 a path radially outwardly from the catheter body into said material and then inwardly
6 towards the catheter body to tension said material; and
7 a cutting element on said catheter body moving between a first position
8 and a second position to cut said material while said material is in tension.

1 37. A catheter for removing material from a body lumen, said catheter
2 comprising:
3 a catheter body having a proximal end, a distal end, and an aperture;
4 a slidable, telescoping portion on said catheter body configured to extend
5 outwardly from said aperture on the catheter body, said telescoping portion having a first
6 open position leaving a gap between one edge of said portion and said catheter body to
7 define a cutter window in which material may intrude to be engaged and having a second
8 closed position wherein said cutting blade is positioned to cut off said material.

1 38. A catheter as in claim 37 wherein said gap defines a side-opening
2 cutter window.

1 39. A catheter as in claim 37 wherein said aperture comprises a
2 forward facing, distal aperture on the catheter body.

1 40. A catheter as in claim 37 further comprising a material capture
2 device mounted on said telescoping portion, said portion moving between a first position
3 and a second position to cut said material while said material is engaged by said material

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4 capture device, wherein motion of the telescoping portion urges the material capture
5 device to draw cut material into the catheter body.

1 41. A catheter as in claim 40 wherein said material capture device is
2 rotatably mounted to said telescoping portion and configured to engage a raised portion
3 on said catheter body to rotate said material capture device to engage material and then
4 draw material into the catheter body.

1 42. A method for excising occlusive material from within a body
2 lumen, said method comprising:
3 capturing said occlusive material with a material capture device on a
4 catheter body;
5 drawing said device radially inwardly towards the catheter body to tension
6 the material; and
7 advancing a blade through the tensioned material to sever said material
8 from the body lumen.

1 43. A method as in claim 42 wherein said engaging of said occlusive
2 material comprises extending said material capture device from said catheter body in a
3 radially outward direction.

1 44. A method as in claim 43 wherein said material capture device does
2 not extend beyond the outer diameter of the catheter body when engaging said material.

1 45. A method as in claim 42 wherein said engaging of said occlusive
2 material comprises penetrating said material with said material capture device.

1 46. A method as in claim 42 wherein said engaging of occlusive
2 material comprises radially extending said material capture device outward from an
3 aperture on the catheter body.

1 47. A method as in claim 46 wherein said engaging of said occlusive
2 material comprises guiding said material capture device against a raised portion on the
3 catheter body to direct said capture device into said material.

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1 48. A method as in claim 46 wherein said engaging of said occlusive
2 material comprises advancing said cutting blade to engage a pushing element against said
3 material capture device mounted on the catheter body.

1 49. A method as in claim 46 wherein said engaging of said occlusive
2 material comprises penetrating said material in advance of the blade and said drawing of
3 said device into the catheter body occurs as the cutting blade is advanced past the
4 aperture.

1 50. A method as in claim 46 further comprising imaging said material
2 prior to cutting said material, wherein said imaging occurs when said aperture is closed
3 by said cutting blade.

1 51. A method as in claim 42 wherein said drawing of the device
2 comprises moving said material capture device radially towards said catheter body while
3 said material capture device remains in contact with said material.

1 52. A method as in claim 51 wherein said drawing of said material
2 capture device occurs when said cutting element is advanced, said cutting element
3 pushing against said material capture device and biasing it into the catheter body.

1 53. A method as in claim 51 wherein drawing of said material capture
2 device comprises positioning said material capture device against a raised portion on the
3 catheter body to guide said device with the material into the catheter body.

1 54. A method as in claim 42 wherein said engaging and tensioning of
2 material are performed through a single motion by the user.

1 55. A method for removing material from a body lumen, said method
2 comprising:
3 positioning a catheter within the lumen;
4 extending a distal portion of the catheter forwardly to open an aperture,
5 wherein material is invaginated into the aperture; and
6 closing the distal portion of the catheter to close the aperture and sever the
7 invaginated material.

1 56. A method as in claim 55, wherein the body lumen is a blood vessel
2 and the material is atheromatous material.

1 57. A method as in claim 55, further comprising penetrating the tissue
2 with a material capture device and drawing the captured material into the aperture with
3 the device as the distal portion of the catheter body is closed.

1 58. A kit comprising:
2 a catheter having a material capture device and a cutting element;
3 instructions for use in removing material from a body lumen comprising
4 engaging said material with a material capture device and tensioning said material
5 towards the catheter while cutting said occlusive material with a cutting element; and
6 a package adapted to contain the device and the instructions for use.

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